

What is claimed is:

1. A three-dimensional (3D) image/two-dimensional (2D) image switching display apparatus comprising:

display unit having a plural of pixel groups  
5 cyclically laid out each comprised of first to n-th pixels  
(n being an integer equal to or greater than 2);

first optical unit which has first optical elements  
cyclically laid out in association with said individual  
pixel groups and refracts lights output from said pixels;  
10 and

second optical unit which has second optical elements  
cyclically laid out in association with said individual  
pixel groups and refracts lights output from said first  
optical unit, wherein when images displayed by said first to  
15 n-th pixels differ from one another, said second optical  
unit is placed in relative to said first optical unit at a  
first position where said first and second optical unit  
output lights, output from said first to n-th pixels, in  
first to n-th directions different from one another, and  
20 when said first to n-th pixels display a same image  
independently, said second optical unit is placed in  
relative to said first optical unit at a second position  
which is set apart from said first position in a layout  
direction of said second optical elements by half a distance  
25 of a layout cycle of said second optical elements or by a  
distance equal to an integer multiple of said layout cycle  
of said second optical elements added to said half the  
distance and where said first and second optical unit output

lights, output from said first to n-th pixels, in a same direction.

2. The 3D image/2D image switching display apparatus according to claim 1, wherein a layout cycle of said first  
5 optical elements is substantially equal to said layout cycle of said second optical elements.

3. The 3D image/2D image switching display apparatus according to claim 1, wherein said display unit has two kinds of pixels, right-eye pixels for a right eye and left-  
10 eye pixels for a left eye, and at a time of displaying a 3D image, said right-eye pixels display images for said right eye, said left-eye pixels display images for said left eye and said first and second optical unit output lights output from said right-eye pixels in a first direction and output  
15 lights output from said left-eye pixels in a second direction, and at a time of displaying a 2D image, said right-eye pixels and said left-eye pixels together display a same 2D image and said first and second optical unit output lights output from said right-eye pixels and said left-eye  
20 pixels in a same direction.

4. The 3D image/2D image switching display apparatus according to claim 3, wherein said first optical unit is a first lenticular lens portion which comprises one or plural convex type lenticular lenses and where said first optical  
25 elements are lens elements, said second optical unit is a second lenticular lens portion which comprises one or plural convex type lenticular lenses and where said second optical elements are lens elements, at a time of displaying a 3D

image, an optical axis of that lens element which is located at a center of said second lenticular lens portion substantially coincides with an optical axis of one lens element of said first lenticular lens portion, and at a time  
5 of displaying a 2D image, said optical axis of said lens element located at said center of said second lenticular lens portion is shifted from an optical axis of that lens element which is located at a center of said first lenticular lens portion, by half a length of a layout cycle  
10 of said lens elements of said second lenticular lens portion or a length equal to an integer multiple of said layout cycle of said lens elements of said second lenticular lens portion added to said half the length.

5. The 3D image/2D image switching display apparatus  
15 according to claim 4, wherein at least one of said first and second lenticular lens portions comprises two or more lenticular lenses stacked one on another.

6. The 3D image/2D image switching display apparatus according to claim 4, wherein a lens side of said first  
20 lenticular lens portion is so arranged as to face a lens side of said second lenticular lens portion.

7. The 3D image/2D image switching display apparatus according to claim 4, wherein a lens side of said first lenticular lens portion and a lens side of said second  
25 lenticular lens portion are so arranged as to face in a same direction.

8. The 3D image/2D image switching display apparatus according to claim 4, wherein a curvature of said lens

elements of said first lenticular lens portion is equal to a curvature of said lens elements of said second lenticular lens portion and in case where said first and second lenticular lens portions are considered as a single virtual lenticular lens, a curvature of lens elements of said virtual lenticular lens is twice said curvature of said lens elements of said first and second lenticular lens portions.

9. The 3D image/2D image switching display apparatus according to claim 4, wherein a curvature of said lens elements of said first lenticular lens portion is equal to a curvature of said lens elements of said second lenticular lens portion and in case where said first and second lenticular lens portions are considered as a single virtual lenticular lens, a clearance between said first and second lenticular lens portions is equal to or less than 20% of a focal distance of lens elements of said virtual lenticular lens.

10. The 3D image/2D image switching display apparatus according to claim 4, wherein at a time of displaying a 3D image, an amount of deviation between said optical axis of said lens element which is located at said center of said first lenticular lens portion and said optical axis of said lens element which is located at said center of said second lenticular lens portion is equal to or less than 12% of a layout cycle of said lens elements of said first lenticular lens portion.

11. The 3D image/2D image switching display apparatus according to claim 4, wherein said first and second

lenticular lens portions are provided respectively movable in relative to said display unit, at a time of displaying a 3D image, said optical axes of said lens elements which are located at said centers of said first and second lenticular lens portions pass through a center of that pixel group, consisting of said right-eye pixels and said left-eye pixels which is located at a center of said display unit, and at a time of displaying a 2D image, said optical axis of said lens element which is located at said center of said first lenticular lens portion passes through a position shifted from said center of said pixel group by a length of  $1/4$  times a layout cycle of said lens elements of said first lenticular lens portion or a length equal to an integer multiple of said layout cycle of said lens elements of said first lenticular lens portion added to said length of  $1/4$  times said layout cycle and said optical axis of said lens element which is located at said center of said second lenticular lens portion passes through a position shifted, in an opposite direction to a direction of shifting done with respect to said display unit, from said center of said pixel group by a length of  $1/4$  times said layout cycle or a length equal to an integer multiple of said layout cycle of said lens elements of said second lenticular lens portion added to said length of  $1/4$  times said layout cycle.

12. The 3D image/2D image switching display apparatus according to claim 4, wherein at a time of displaying a 2D image, a width of a 2D visible range over which a light emitting section of a pixel is projected in magnification is

set greater than a distance between both eyes of an observer.

13. The 3D image/2D image switching display apparatus according to claim 4, wherein at a time of displaying a 3D image, a width of a 3D visible range over which light output  
5 from a pixel is projected in magnification via that lens element which is closest to that pixel is set twice a distance between both eyes of an observer.

14. The 3D image/2D image switching display apparatus according to claim 1, wherein one of said first and second  
10 optical unit is a convex lenticular lens portion which comprises one or plural convex type lenticular lenses, the other one of said first and second optical unit is a concave lenticular lens portion which comprises one or plural concave type lenticular lenses, at a time said first to n-th  
15 pixels respectively display first to n-th images, an optical axis of that lens element which is located at a center of said convex lenticular lens portion is shifted from an optical axis of that lens element which is located at a center of said concave lenticular lens portion, by half a  
20 length of a layout cycle of said lens elements of said convex lenticular lens portion or a length equal to an integer multiple of said layout cycle of said lens elements of said convex lenticular lens portion added to said half the length, and at a time said first to n-th pixels  
25 respectively together display a same image, said optical axis of said lens element located at said center of said convex lenticular lens portion substantially coincides with an optical axis of one lens element of said concave

lenticular lens portion.

15       15. The 3D image/2D image switching display apparatus according to claim 14, wherein at least one of said convex lenticular lens portion and said concave lenticular lens portion comprises two or more lenticular lenses stacked one on another.

10       16. The 3D image/2D image switching display apparatus according to claim 1, wherein said first optical unit is a first fly-eye lens portion which comprises one or plural fly-eye lenses, said second optical unit is a second fly-eye lens portion which comprises one or plural fly-eye lenses, and said second fly-eye lens portion is movable in all directions in which said pixels of said display unit are laid out in relative to said first fly-eye lens portion.

15       17. The 3D image/2D image switching display apparatus according to claim 16, wherein at least one of said first and second fly-eye lens portions comprises two or more fly-eye lenses stacked one on another.

20       18. The 3D image/2D image switching display apparatus according to claim 16, wherein said display unit has first to fourth pixels laid out in a matrix form of two rows by two columns and said first and second fly-eye lens portions comprise convex type fly-eye lenses.

25       19. The 3D image/2D image switching display apparatus according to claim 16, wherein at least one of said pixels is a right-eye pixel for a right eye and at least one of the other pixels is a left-eye pixel for a left eye, at a time of displaying a 3D image, said right-eye pixel displays an

image for said right eye, said left-eye pixel displays an  
image for said left eye and an optical axis of that lens  
element which is located at a center of said second fly-eye  
lens portion substantially coincides with an optical axis of  
5 one lens element of said first fly-eye lens portion, and at  
a time of displaying a 2D image, said optical axis of said  
lens element located at said center of said second fly-eye  
lens portion is shifted from an optical axis of that lens  
element which is located at a center of said second fly-eye  
10 lens portion, in a direction going toward said image for  
said left eye from said image for said right eye or a  
direction opposite thereto, by half a length of a layout  
cycle of said lens elements of said second fly-eye lens  
portion or a length equal to an integer multiple of said  
15 layout cycle of said lens elements of said second fly-eye  
lens portion added to said half the length.

20. The 3D image/2D image switching display apparatus  
according to claim 1, wherein said first optical unit is a  
first prism plate on which prism elements are laid out, said  
20 second optical unit is a second prism plate on which prism  
elements are laid out, at a time of displaying a 3D image, a  
vertex of that prism element which is located at a center of  
said second prism plate, as seen from a direction  
perpendicular to a display surface of said display unit,  
25 substantially coincides with a trough portion between one  
prism element of said first prism plate and those prism  
elements which adjoin that one prism element, and at a time  
of displaying a 2D image, said vertex of said prism element



which is located at said center of said second prism plate, as seen from said direction perpendicular to said display surface of said display unit, substantially coincides with a vertex of one prism element of said first prism plate.

5           21. The 3D image/2D image switching display apparatus according to claim 1, wherein said display unit has a color filter which colors lights output from said pixels and has a plurality of stripe portions colored to plural kinds of colors and cyclically laid out in parallel to one another  
10           and a lengthwise direction of said stripe portions is parallel to layout directions of said first and second optical elements.

          22. The 3D image/2D image switching display apparatus according to claim 1, wherein said display unit displays an  
15           image by color field sequential display method.

          23. The 3D image/2D image switching display apparatus according to claim 1, further comprising a casing which houses said display unit and said first and second optical unit and to which said second optical unit is fixed.

20           24. The 3D image/2D image switching display apparatus according to claim 23, wherein said second optical unit has a capability of a protection plate, a touch panel or a front-light for said display unit.

          25. The 3D image/2D image switching display apparatus  
25           according to claim 1, wherein at least one part of said first optical unit is formed integral with a member which constitutes a display surface of said display unit.

          26. The 3D image/2D image switching display apparatus

according to claim 1, wherein at least one of said first and second optical unit is divided into a plurality of portions as seen from a direction perpendicular to a display surface of said display unit and said plurality of portions are  
5 movable independently of one another.

27. The 3D image/2D image switching display apparatus according to claim 1, wherein at least one of said first and second optical unit is provided with a frame.

28. The 3D image/2D image switching display apparatus  
10 according to claim 1, wherein an antireflection coating is formed on a surface of at least one of said first and second optical unit.

29. The 3D image/2D image switching display apparatus according to claim 1, further comprising an actuator,  
15 attached to at least one of said first and second optical unit, for moving said one of said first and second optical unit in relative to the other optical unit.

30. The 3D image/2D image switching display apparatus according to claim 1, further comprising a casing for  
20 housing said display unit and said first and second optical unit, and

one pair or plural pairs of non-linear springs which are located between said casing and at least one of said first and second optical unit in such a way as to be  
25 stretched and contracted in a layout direction of said first optical elements and whose reaction force is discontinuously reduced when an amount of displacement exceeds a threshold value, and which are provided in such a way that an amount

of displacement of one of each pair of non-linear springs is greater than said threshold value while an amount of displacement of the other non-linear spring becomes smaller than said threshold value.

5           31. The 3D image/2D image switching display apparatus according to claim 30, wherein at least one pair of non-linear springs is coupled to an edge extending in a direction perpendicular to said layout direction in said one of said first and second optical unit.

10           32. The 3D image/2D image switching display apparatus according to claim 29, wherein said actuator is a linear member made of a shape memory alloy and connected to a power supply.

15           33. The 3D image/2D image switching display apparatus according to claim 1, wherein said display unit is a liquid crystal display unit.

34. A portable terminal device having a 3D image/2D image switching display apparatus according to claim 1.

20           35. The portable terminal device according to claim 34, wherein said portable terminal device is a portable telephone, a portable terminal, PDA (Personal Digital Assistant), a game machine, a digital camera or a digital video.